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being by no means steady and uniform, but subject to alternating changes of greater or less amount. The effects exhibited on these wires, and which, from the experiments, were found to occur on the north of Derby as well as on the south, would be accounted for by supposing that they were caused by alternating currents of electricity on the earth's surface in a northerly and southerly direction, proceeding towards the north until 9 A.M., and towards the south until from 7 to 12 P.M., and then again turning northwards; agreeing, therefore, nearly in point of time with the usual times of daily change in the direction of the magnetic needle. The experiments, as has been stated, were continued during a fortnight, and the deflection noted every five minutes, day and night. The paper contains the tabular records of these observations; and also diagrams are given exhibiting the daily path of the needle.

The author concludes his paper by expressing his regret that his avocations do not allow him sufficient leisure to prosecute this inquiry, but that he will be happy to place in the hands of any person desirous of pursuing the subject all the tables and results which he has collected.

5. "On the Direction assumed by Plants during their growth." By Professor Macaire, of Geneva. Communicated by P. M. Roget, M.D., Sec. R.S., &c.

This paper is divided into three sections.

The first section contains an account of some observations and experiments made by the author on the phenomena of the curling of the tendrils of the *Tamus communis*. After a description of the tendril, which in this plant is the footstalk of an abortive leaf, the author shows that the contractile power of the organ is excited by contact with any object whatsoever, and even with another part of the same plant; that the curling begins at the point of contact, but continues in both ends of the tendril, either forming knots, if there be something to embrace, or taking the shape of a cork-screw, if there be not. The knots are completed in a few minutes, and exert a considerable degree of pressure. A separation from the plant stops the curling up of the tendril. The curling always takes place in the same direction from the outside inwards. When the tendril is immersed in water, or in a solution of gum, it does not contract; but at the same time it does not lose the faculty of curling up by contact with a solid body. Ammonia, alcohol, or Eau de Cologne have little or no effect. Diluted sulphuric and nitric acids, even the vapours alone of the last, without actual contact, immediately excite in the tendril an energetic contraction. The same thing happens with a solution of corrosive sublimate. On the contrary, prussic acid stops the curling up that had already begun, and renders the tendril incapable of being again excited by the contact of a solid body.

The conclusions which the author comes to on this subject are, that the contractions of tendrils cannot be explained by the hypotheses of Knight and De Candolle of an unequal action of light on

the two sides, for they are too rapid to be the effect of so slow a process ; but that they are the result of a vital property residing in the organ, on which the poisons act as they do on the sensitive plant.

The second section relates to the direction of stems towards the light. After having described the nature of the phenomenon, and stated the explanation of it given by De Candolle, namely, the bending of the stem by an accumulation of carbon and the consequent hardening of the side most acted upon by light, the author endeavours to ascertain if the light exercises a real attraction for the green parts of plants. He operated on naturally floating plants, such as the duckweed (*Lemna minor* and *Polyrhina*), and on different species of other plants placed on cork floats. He placed each of them on water in vases which were partly darkened by screens, and he never saw the plants receiving from the light an impulsion which brought the floats away from the spot where they had been placed. When the plants, fully developed, were kept in the dark part of the vase, there sprouted from the neck of the root a new stem, slender and blanched, that ran all along the water so as to reach the diaphragm, and then gave out leaves and grew erect ; but the float was never attracted towards the light, although the new stem which the plant had to produce was often three feet and more in length. In the course of these experiments, he had occasion to notice the tendency of roots when developed in the light in water, to take a spiral shape, and found that the white light appears to favour the production of radicular fibrils, while, on the contrary, the blue light opposes it.

In examining the grounds of Dutrochet's theory on the existence in stems of two systems of cells and fibres decreasing in size from the circumference to the centre, and from the centre to the circumference, by which he explains by endosmose the bending of the stem, the author has found that this bending in contrary directions of the two parts of a stem slit longitudinally has nothing to do with light. In cutting the stem in various directions, it always bends outwards by the swelling of the cells and the resistance of the cuticle, and does not bend at all if this last is removed or slit across in two or three places.

To ascertain if the sap could be supposed to travel by endosmose from cell to cell, he placed within one another three endosmose tubes filled with a solution of sugar ; the last, or largest, plunging in water. This was the only one in which any endosmose was visible, the difference in density from the others being insufficient to produce it. It is probable that it would be the same for the cells of plants ; and some facts have induced him to think that the liquids penetrate chiefly through the intercellular spaces of the vegetable tissue. He has assured himself by experiments that neither heat nor light have any influence in increasing the quantity or the rapidity of endosmose, and he is, consequently, little inclined to admit this phenomenon as exercising the influence sometimes attributed to it in vegetation, and especially in the inclination of stems towards the light.

The third section relates to the direction of the leaves of plants. After having described the appearance and structure of the two surfaces of leaves, and mentioned the known fact of the direction of the superior or varnished surface towards the light, the author reviews the labours of Bonnet and Dutrochet on this subject. As no direct experiments had proved that the direction of leaves is due to the influence of light itself, he begins by showing, first, that the turning over of inverted leaves does not take place regularly in complete obscurity; secondly, that it is possible to induce a leaf to turn itself over by screening its superior surface, and by lighting its inferior one with an inclined mirror; and thirdly, that when both the surfaces of the leaf are illuminated, the leaf takes a globular form so as to protect the inferior surface from the light. He afterwards shows that although in most plants the turning over of inverted leaves takes place through a movement of the footstalk, yet in some of them it is the flat part of the leaf that curls itself over, and that in all the same thing happens when it is the best way of bringing back the superior surface of the leaf towards the light. This is the case, for instance, when the footstalk has been removed, and when the inferior surface is lighted by a mirror and the superior one is screened by a piece of black paper fixed to it. The flat part of the leaf bends its edges and takes a globular form.

The two surfaces of the leaf do not seem to be under the influence of any real attraction towards the light, for when placed in an inverted position on moveable floats, the leaf turns itself over by means of the footstalk, or the curling of the flat part, without creating any motion in the float. The removal of one or many leaflets in a compound leaf, or of part of a single leaf, does not prevent the turning over of the remainder when placed towards the light in an inverted position. By means of coloured glasses, the purity of the light of which had been ascertained by the prism, it has been shown that the leaves turn over best in the blue rays; next in the violet, but not at all in the red.

The author next examines the differences produced in the power of leaves to exhale and decompose carbonic acid, according as the light shines on one or other of their surfaces. In order to measure the exhalation, he placed in a bottle full of water of known weight, a leaf with one of its surfaces darkened and the other exposed to light, changing the surfaces alternately while the experiment lasted. The result of a great many series of experiments has been to show that the loss of water by exhalation in all temperatures and by all weathers is much more considerable during the same time when the inferior surface of the leaf is exposed to light, than when the superior surface is so exposed. This increase explains the rapid withering and subsequent death of inverted leaves which cannot turn themselves over. In coloured glasses the blue rays created the greatest exhalation; next the diffused white light; next the green; the red rays coming last.

On examining, under the same circumstances, the decomposition of carbonic acid, the author first sought in what part of the leaf this

chemical power resided. He found that the green matter did not possess it in itself, that it operated in the cells of the parenchyma, and that the vessels and pores of the cuticle have a useful influence in the phenomenon, so as to increase the quantity of oxygen gas disengaged. When solar light is received on the superior surface of leaves immersed in spring water, the quantity of oxygen gas disengaged is, in the same time and under similar circumstances, two or three times greater than when it is received on the inferior surface. The same difference may be observed in the diffused light, by means of the leaves of *Camellia japonica*, Portugal laurel, and some others which, when kept during some time in the dark in spring water, give out, when brought into the light, bubbles of oxygen gas through the central vessels of the footstalk.

The following is a brief recapitulation of the facts which the author has attempted to prove in this paper:—

1. The theories advanced to explain the curling up of tendrils, do not agree with the experiments made on those of the *Tamus communis*, this phenomenon being the result of a vital irritability acted upon by chemical agents.

2. The direction of the green parts of plants towards the light is not the result of an attraction properly so called.

3. The bending outwards of slit stems is due to the elongation of the cellular tissue by endosmose of water and the resistance of the cuticle.

4. The quantity or rapidity of endosmose is not influenced by heat or light.

5. Light is the only agent of the natural position of leaves and of their turning over when inverted. The blue are the most, the red the least active rays.

6. Light does not act in this case by a physical attraction or repulsion, properly so called.

7. The turning over of leaves takes place sometimes by a torsion of the footstalk, sometimes by a curling of the flat part.

8. The blue rays appear to be the most, and the red the least active in operating the turning over of leaves.

9. The exhalation of leaves is much increased when their inferior surface is exposed to light.

10. The decomposition of carbonic acid and the disengagement of oxygen gas are, under the same circumstances, considerably diminished.

6. "On the Solution of Linear Differential Equations." By Charles James Hargreave, Esq., B.L., F.R.S., Professor of Jurisprudence in University College, London.

1. By the aid of two simple theorems expressing the laws under which the operations of differentiation combine with operations denoted by factors, functions of the independent variable, the author arrives at a principle extensively applicable to the solution of equations, which may be stated as follows:—"if any linear equation  $\phi(x,D).u = X$  have for its solution  $u = \psi(x,D).X$ , this solution being